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ABSTRACT

An economic model of educational supply and demand was tested using cross-sectional data for the 95 Virginia county school districts. Three equations were hypothesized: (1) the quantity supply functions; (2) the quantity demand function; and (3) the quality demand function. The variables in the equations are education expenditures, percent of 9th grade students graduating in 4 years, 11th grade reading achievement test scores, mean per capita income, percent of adults 25 years old or older with a high school diploma, employment rate, rural or urban district, and percent of non-white population. The model was fitted with data obtained from the 1980-81 report on local government expenditures and from the 1980-81 state department of education publication on schools. The equations were estimated with three stage least squares. The variation explained by the model (weighted R-squared) was .6328. Rank and order condition for identification were met. The results of the study suggest that decisions regarding education services can be meaningfully viewed as a simultaneous consideration of benefits and costs. (JHZ)

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A SIMULTANEOUS MODEL OF EDUCATION SUPPLY AND DEMAND

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A SIMULTANEOUS MODEL OF EDUCATION SUPPLY AND DEMAND

INTRODUCTION

This paper develops an economic model that simultaneously accounts for supply and demand factors in determining the equilibrium level of education service in a community. The model also considers the joint product nature of education production by incorporating measures for both the quantity and the quality dimensions of education. The trade-off between quality and quantity is of particular interest.

Investments in education are important to individuals because of private returns in the form of future income and access to opportunity (Becker). Education investments increase the qualities of citizenship and provide such external benefits as a stable community and economic growth (Hines, Tweeten and Redfern). Because of these external benefits, or jointness of consumption of education output, education is largely provided as a public service in this country and in most of the world.

Despite the recognized importance of education investments to both individuals and the community, research on the supply and demand relationships of education has been limited. The lack of a theory of learning to guide specification of the technical relationships in education production and difficulties identifying and measuring education outputs (Burkhead) clearly have presented researchers with major obstacles.

Prior education demand research has generally been one of two types: reduced form expenditure functions or derived demand functions for years of schooling. The reduced form expenditure function studies (Conlisk, Hirsch, Miner) have shown per capita

income, community wealth, and community size to be significant in explaining local expenditure levels for education. While these studies provide valuable insights, their results are sometimes difficult to relate to the processes involved in education production and demand. Since the proxy used for education output is a measure of input intensity rather than output, the studies provide information on economies of size. Changes in quality and quantity can be determined only if very limiting assumptions are made about the relationships between input and output.

The other type of education demand study uses household production theory (Edwards, Rosenzweig, Barichello) as a theoretical framework for developing equations for households' derived demand for education. These models use years of schooling as the education output measure. This measure does not distinguish among the quality and achievement differences that occur for different individuals for a given number of years.

Hambor, Phillips and Votey estimated the optimal community education attainment level using a simultaneous equation model with a demand function and a cost function. Their output measure, the ratio of selective service test passes to failures, is difficult to relate to education outputs and does not differentiate between quality and quantity dimensions of education outputs, or recognize the multi-product nature of education production.

EDUCATION SUPPLY AND DEMAND

Educational production is influenced by the human capital demands of households, businesses and the community, as well as, complex technical relationships in the education production process. In order to understand the process of education provision, both demand and supply factors and the interrelationships and trade-offs between the quantity and quality dimensions of education production must be understood.

OUTPUT Specification of public service outputs is problematic for economic researchers. Ostrom argues for the development and use of multiple output measures for public services to better understand the supply and demand relationships and to provide decision makers with research insights that will enable them to improve productivity. Hirsch, also urging researchers to develop more meaningful public service output measures, suggests that both the quality and quantity dimensions be considered in analysis of the public sector. This study models the relationships between the demand for quality and quantity.

DEMAND FACTORS A community's demand for education is a result of needs for human capital by households, private firms and public sectors. Demand factors include tastes and preferences, economic access issues, and social needs. These factors jointly affect demand both for education quantity and quality. Analysts, therefore, must consider quantity and quality simultaneously to identify the factors that influence demand for education.

JOINT CONSUMPTION Education has significant public good

charateristics--that is, it is consumed jointly by the entire community. As a result, the community demand for education is the vertical sum of demand by individuals (i.e. their value of marginal product curves). At the same time, the public service aspect of education means that the marginal cost of education to individuals is determined by the tax system. For the average constituent, the marginal cost of education is his or her tax share times the district's marginal cost of education, or the districts marginal cost divided by the number of tax payers.

The level of education provided in a given community is assumed to be determined through a political process that achieves equilibrium at the point where the marginal social benefits of education equal the marginal social costs. Government officials and school administrators must simultaneously consider the marginal costs and benefits, to their constituents, of each additional unit of quality and quantity of education output.

MODEL FORMULATION Given the decision model hypothesized above, and applying Hirsch's quality/quantity distinction to education, the supply and demand model is hypothesized to be as follows:

(1) QPRICE = f(QUAN, QUAN2, QUAL, SALARY)

(2) QUAN = f(QPRICE, QUAL, INCOME, GRADS, UNEMP)

(3) QUAL = f(QPRICE, INCOME, PCRACE, RURAL)

Definitions for each of the variables are presented in table 1. All measures are county level averages for Virginia's 95

counties. School districts in Virginia are coincident with county and city jurisdictions

Considering the non-market nature of education and the joint nature of quality and quantity production, it is difficult to develop meaningful measures for the price of education quality and quantity. Like a somewhat heterogeneous private market good, a single supply function is specified in this education model. Education quality is included in the quantity supply function as a cost factor (i.e. shifter).

Equation (1) is the quantity supply function. It is based on the hypothesis that the per unit cost of school quantity is a positive function of the quality of education and of teacher salary (a measure of input cost levels). While marginal cost of providing education may have been a preferable measure, it was not (and rarely is) available. Furthermore, it is arguable that since school districts must balanced budgets (at least in the long run), decision makers consider average rather that marginal cost. The quantity squared is included in the equation along with quantity to allow for a non-linear cost curve.

The quantity demand function is presented in equation (2). Quantity demanded is hypothesized to be a negative function of the cost of education quantity and of the quality of education, and a positive function of per capita income, the percent of adults with high school diplomas, and the unemployment rate.

The quantity measure is the percent of ninth grade students who graduate from high school four years later. This measure is used for two primary reasons. First, it is based on a socially accepted standard of educational achievement. That is,

the measure views the high school diploma as the an output that is produced over a twelve year production period. Second, using the rate at which schools graduate high school students provides a relative production rate that can be applied across school districts.

The quantity price used in the model, the total expenditures divided by the number of high school graduates, also focuses on the high school diploma as the quantity product of the education system while reflecting the fact that all constituents share in funding through the tax system. Price is expected to have a negative relationship to the quantity demanded.

Education quantity is hypothesized to be inversely related to quality because of evidence in prior research (Katzman) that suggests that higher education quality is associated with a higher school dropout rate. Including the quality measure will provide a test of the hypothesis that quality and quantity are trade-off characteristic of education. Education quantity is assumed to be a normal good, and therefore positively related to income. Demand for quantity of education is assumed to be positively related to the educational level of the community as measured by GRAD (the percentage of the adult population with highschool diplomas).

The unemployment rate is included in the quantity demand equation as a measure of economic opportunity. Barichello's farm family household demand research suggests that families that expect children to migrate for employment opportunity demand a higher level of education quantity. The unemployment rate,

therefore, is hypothesized to be positively related to quantity demanded on the assumption that higher unemployment rates increase the potential need for migration for employment opportunity. On the other hand, high unemployment may reduce the expectation for rewards and, hence, lower demand.

The quality demand function is given in equation (3). The quality measure is the Scientific Research Associates Standardized Achievement Test score (SRA) for the 11th grade. All Virginia public school students are required to take this test in grades 4, 8, and 11. Education quality is hypothesized to be inversely related to the price of education quantity. Quality is assumed to be a normal good and, therefore, positively related to income. RURAL, the dummy-variable for rural location is included in the model to test whether the economic and social structures of the community have an impact on education quality demand. It is hypothesized that rural communities demand less education quality because of fewer skill needs in rural job markets and higher costs for post secondary education. The non-white percentage of population is included in the quality demand model to measure whether the historical barriers to education that have faced non-whites in Virginia are evidenced by less demand for quality education in the non-white community. The measure is hypothesized to be negatively related to demand for education quality.

TABLE 1: Definition of Variables

Variable	Definition
QPRICE	county education expenditures divided by the number of graduates
QUAN	percent of ninth grade student graduating 4 years later
QUAN2	QUAN measure squared
QUAL	11th grade SRA reading achievement test score
INCOME	county mean per capita income
GRADS	percent of adults 25 years old or older with a high school diploma
UNEMP	county unemployment rate
RURAL	binary 1 = rural district, 0 = urban district
PCRACE	percent of population non-white in county

EMPIRICAL RESULTS

The model was fitted with cross sectional data for the 95 Virginia counties. (School districts in Virginia are units of county government). The data were obtained from the 1980-81 report on local government expenditures and from the 1980-81 state department of education publication on schools. The equations were estimated with three stage least squares. The variation explained by the model (weighted R-squared) is .6328. Rank and order condition for identification were met. Equation 3, the quality demand function is over identified by 3. Equations 1 and 2, the quantity supply and demand functions are both over identified by 2. The results are presented in table 2.

The estimated supply and demand equations for education

TABLE 2: Three Stage Least Squares Results for Education Supply and Demand Model

	SUPPLY	DEMAND QUANTITY	DEMAND QUALITY
	QPRICE	QUANT	QUAL
INTERCEPT	164740.46	140.06	46.11
QPRICE		-.0027**	-.0006*
		(-5.76)	(-2.36)
QUAN	-3702.77		
	(-1.83)		
QUAN2	22.73		
	(1.64)		
QUAL	140.66	-.1327	
	(1.65)	(-.48)	
INCOME		.0024**	.0023**
		(2.56)	(4.86)
GRADS		-.0045	
		(-.02)	
UNEMPLOY		.1634	
		(.40)	
RURAL			-4.32**
			(-3.27)
PCRACE			-.2410**
			(-3.27)

t-statistics in parentheses
** significant at the .01 level
* significant at the .05 level
Weighted R-Squared for system = .6328

quantity are plotted figure 1. Curves S1 and D1 are plotted with mean values while S2 and D2 use maximum observed values for the quality variable. Note that the increase in quality from a mean SRA score of 38.7 to a maximum of 66.0 shift the quantity supply curve up and the quantity demand curve down.

The estimated functions in table 2 indicate that salary levels also shift the supply curve up as expected. The U-shaped supply curve indicates that the initial declines in costs per grads, as fixed costs are spread over more students, are eventually offset by rapidly rising variable costs as the school district spends to increase the percent of students graduating, while holding quality constant.

The price and income variables in the quantity demand curve are significant with signs as hypothesized. The negative sign on the price variable indicates the usual relationship between quantity demanded and price. The income measure is positive, suggesting that education quantity is a normal good. The quality and unemployment measures, while insignificant, have the expected sign. The community education level measure is insignificant, suggesting that parents' educational attainment is not a good predictor of demand for education quantity. Perhaps the income variable has accounted for this hypothesized effect of community education level. The coefficient on unemployment suggests that local unemployment is not a factor in education consumption decisions.

All four of the exogenous variables in the education quality demand function were significant. The quality equation, while not

containing its own price measure, is interpreted as a demand equation in which its implicit "shadow price" is fixed at the partial derivative of the supply curve for quantity with respect to quality (i.e. $140.66 per SRA percentile). The estimated equation indicates that quality is a normal good, and that it is valued less in the more rural counties and in those counties in which the nonwhite population is higher. Each of these supports the earlier hypotheses.

The results of this study suggests that decisions regarding education services can be meaningfully viewed as a simultaneous consideration of benefits and costs. The quantity of education, from the perspective of constituents is the number of graduates per 100 student (that is, the probability that an average student will graduate). The marginal benefits of education decline as this level approaches 100%. The cost of education eventually increases as this maximum level is approached.

The results indicate very clearly that quality and quantity are traded off in decisions relating to education. This trade off involves two components. First, higher quality education (quantity held constant) is costly ($141 per percentile on the SRA tests for each graduate in 100 students). This increased cost per unit reduces quantity demanded by .38 (-.0027 X $141) grads per 100. At the same time the increased quality results in a shift in the demand curve for quantity which further reduces quantity demanded by .13 grads per 100. This isolation of factors is useful in understanding the processes involved in education service provision.